EXPERIMENTAL TOWING TANK
STEVENS INSTITUTE OF TECHNOLOGY

# REPORT NO. 313

## GENERAL MAIN-SPRAY TESTS IN THE DISPLACEMENT SPEED RANGE OF THREE FLYING-BOAT HULL MODELS OF VARYING LENGTH-BEAM RATIO

by

W. C. Hugli, Jr.

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HOBOKEN, NEW JERSEY
FEBRUARY, 1947



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GENERAL MAIN-SPRAY TESTS

IN THE

DISPLACEMENT SPEED RANGE

OF

THREE FLYING-BOAT HULL MODELS

OF

VARYING LENGTH-BEAM RATIO

for

National Advisory Committee for Aeronautics

(NASA TM X-50577 ; (REPORT NO. 313) (NASA Contract NASw-5316)

by

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February 1947 5 refs

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8360000

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## INTRODUCTION

The purpose of the investigation herein reported was to provide additional information on the main spray characteristics of a series of previously tested flying-boat hull models. The investigation was authorized by the National Advisory Committee for Aeronautics, and constitutes a portion of the work to be done under Contract No. NAw5316, dated April 4, 1946.

Earlier, the hydrodynamic characteristics of a series of 21 hull models — three length-beam ratio groups of seven hulls each — were investigated over a wide loading range by the "general" method (Reference 1). The main spray characteristics of these 21 hulls were obtained over the loading range for the zero trimming-moment condition. A comprehensive spray investigation can be made only by testing over a range of speeds and trim angles, since other spray studies (References 2 and 3) have shown that the main spray characteristics of a given flying-boat hull are influenced by trim angle. Such an investigation should give the trim track which produces minimum spray heights in the vicinity of the propellers and wing flaps. The present tests, which supplement the earlier tests, were made to determine the spray heights over a range of trim angles, which were obtained by varying the trimming-moments at speeds in the displacement range.

Supplementary tests on all of the 21 hulls were not believed necessary, since the spray characteristics of the hulls within a length-beam ratio group had been found to be similar. Consequently, only three hull models were tested — the "middle" hull of each length-beam ratio group.

This report presents the test data, together with a brief discussion. The results of the general main spray tests are given in a form which shows the maximum spray height occurring at any speed, at the propeller and wing flap locations, and for loadings and trimming-moments within the test ranges.

## MODELS

The "middle" hull of each length-beam ratio group of the series of models tested under NACA Contract No. NAw3688 and reported in Reference 1 was used in the present tests. They are:

| ETT Model No. | Designation | Description |
|---|---|---|
| 654 | 6-58-08 | 6 = length-beam ratio<br>58 = length of forebody in percent of length from forepoint to sternpost<br>08 = step depth at keel in percent of beam |
| 634 | 8-58-10.66 | |
| 685 | 10-58-13.33 | |

The body sections and profiles of the hulls are shown on pages 7 to 9 . Pertinent dimensions and particulars are provided on the drawings; further information can be found in Reference 1.

All models were built to the same beam of 5.40 inches. For all tests, the center of gravity was located 0.35 beam forward of the step centroid and 0.90 beam above the forebody keel.

## PROCEDURE

Reference 4 describes the present method used for making main spray tests and recording the data with three-view photographs.

Each hull was tested at the same series of constant loads used in the earlier investigation (Reference 1), but with various nose-downward applied moments instead of the zero moment previously tested. The tests were run at enough speeds to develop the maximum spray height in the vicinity of the propellers and wing flaps.

All tests were run at a series of constant speeds in substantially smooth water, and at zero heel angle.

## RESULTS AND DISCUSSION

The data obtained on each of the three flying-boat hull models are presented in collapsed form on pages 10 to 18. This method of plotting main spray data is presented and discussed in Reference 5. Superimposed on these charts are the data for zero trimming-moment obtained in the earlier investigation reported in Reference 1.

It is usually desirable to know the maximum spray heights which will be encountered at definite longitudinal positions on the hull — such as propeller and wing flap locations — for various operating conditions. Accordingly, for each of three longitudinal positions, corresponding roughly to the propeller, step and wing flap locations, cross plots which show the maximum spray height and trim angle as functions of load and trimming-moment were constructed from the curves drawn through the data on the collapsed charts. The results, in this cross-plot form are shown on pages 19 to 21 for Model No. 654 (6-58-08), on pages 22 to 24 for Model

No. 634 (8-58-10.66), and on pages 25 to 27 for Model No. 685 (10-58-13.33).

It should be noted that the spray height which is tangent to the blister envelope at a given longitudinal location on the hull does not occur at a fixed speed when the loading and the trimming-moment are varied. The cross plots show, therefore, the maximum height of spray encountered <u>at any speed</u>, at definite longitudinal positions on the hull, and for loadings and trimming-moments within the test ranges.

Charts similar in form to those shown on pages 19 to 27 are, in general, adequate for determining the maximum spray height at any speed, at the propellers or wing flaps for flying-boat hull models under various operating conditions. The spray height corresponding to zero trimming-moment (free-to-trim), or any other assumed trimming-moment coefficient, may be obtained with equal facility. If data are desired for a center of gravity other than the one used in these general tests, the trimming-moment coefficient may be corrected for the difference between the two positions by calculations.

The method considered herein of giving spray heights at fixed longitudinal positions on the hull is not intended to replace, but rather to supplement, the various other forms used to present results of "general" main spray tests. The purpose of these charts is to show the effect of load and trim angle on the maximum spray height at definite longitudinal positions along the hull such as at the propeller and wing flap locations.

## REFERENCES

1. Hugli, W.C., Jr., Strumpf, Albert, and Axt, W.C.: "An Investigation of the Effects of Hull Proportion and Step Depth on the Hydrodynamic Characteristics of Flying-Boat Hull Models with Varying Length-Beam Ratios", Experimental Towing Tank Report No. 312, February 1947.

2. Hugli, W.C., Jr.: "The Influence of Afterbody Length and Angle on the Main Spray Characteristics of a Flying-Boat Hull Model", Experimental Towing Tank Report No. 304, June 1946.

3. Dawson, John R. and Walter, Robert C.: "The Effects of Various Parameters on the Load at Which Spray Enters the Propellers of a Flying Boat", National Advisory Committee for Aeronautics Technical Note No. 1056, May 1946.

4. Locke, F.W.S., Jr., and Bott, Helen L.: "A Method for Making Quantitative Studies of the Main Spray Characteristics of Flying-Boat Hull Models", National Advisory Committee for Aeronautics ARR No. 3K11, 1943.

5. Locke, F.W.S., Jr.: "'General' Main Spray Tests of Flying-Boat Models in the Displacement Range", National Advisory Committee for Aeronautics ARR No. 5A02, April 1945.

# NOTATION AND NON-DIMENSIONAL COEFFICIENTS

The following notation and non-dimensional coefficients are used:

| | |
|---|---|
| Load coefficient, | $C_\Delta = \Delta/wb^3$ |
| Speed coefficient, | $C_V = V/\sqrt{gb}$ |
| Trimming-moment coefficient, | $C_M = M/wb^4$ |
| Longitudinal spray coefficient, | $C_X = X/b$ |
| Vertical spray coefficient, | $C_Z = Z/b$ |

where,

$\Delta$ = load on water, lb.

w = specific weight of water, lb./cu.ft. (62.3 lb./cu.ft. was used in computing load coefficients)

b = beam of hull at step, ft.

V = speed, ft./sec.

g = acceleration of gravity, 32.2 ft./sec.$^2$

M = trimming moment, lb.ft.

X = longitudinal position of main spray point of tangency to blister envelope, measured fore or aft of the main step, ft.

Z = vertical position of main spray point of tangency to blister envelope, measured from tangent to the fore-body keel at the main step, ft.

Trim ($\tau$) is the angle between the tangent to the forebody keel at the main step and the horizontal.

Heel ($\phi$) is the angle between the plane of symmetry and the vertical.

All moments are measured about the center of gravity, and water trimming-moments tending to raise the bow are considered positive.

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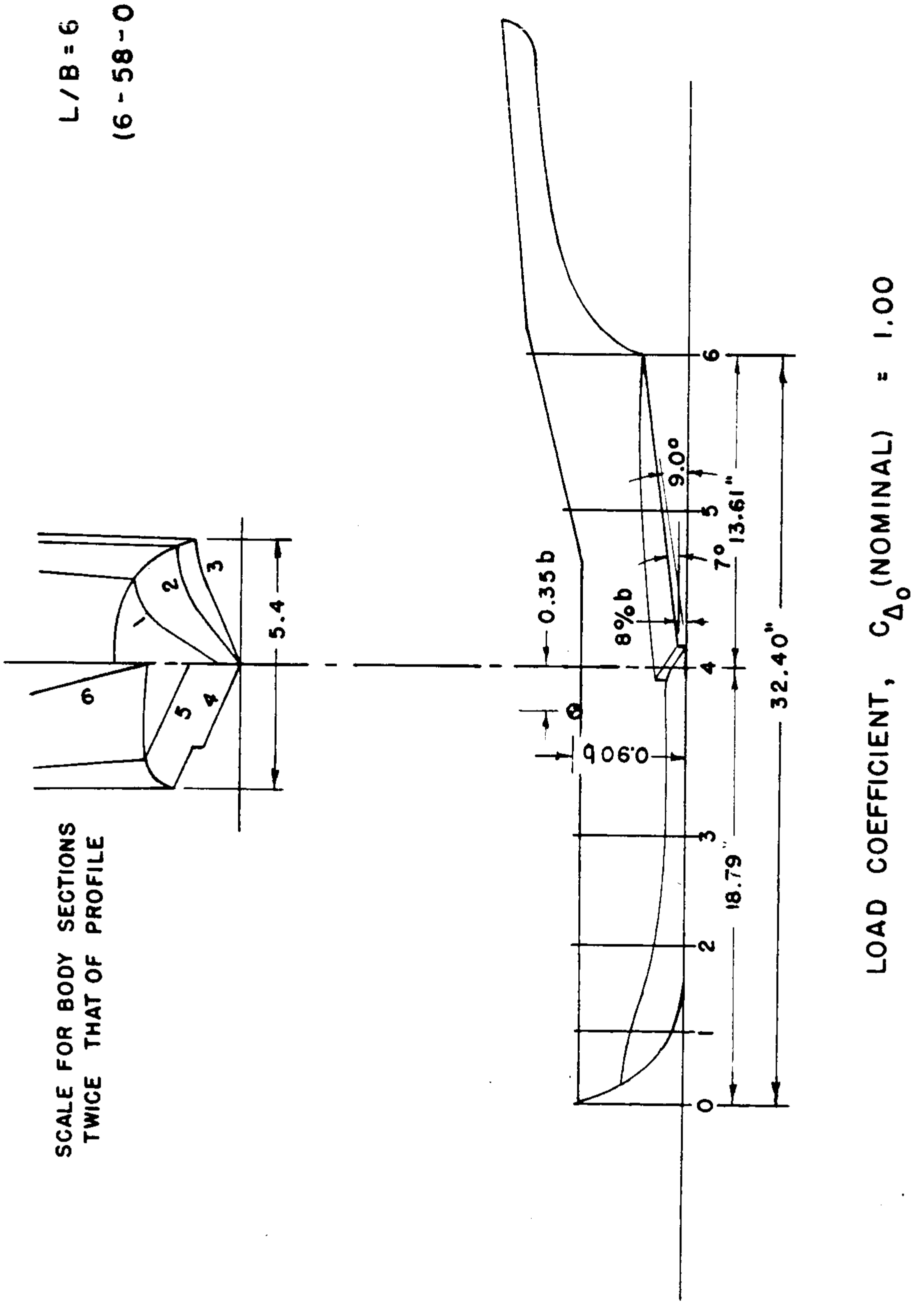
HULL LINES
MODEL NO. 654




REFERENCE: N.A.C.A. CONTRACT NO. NAW 3688

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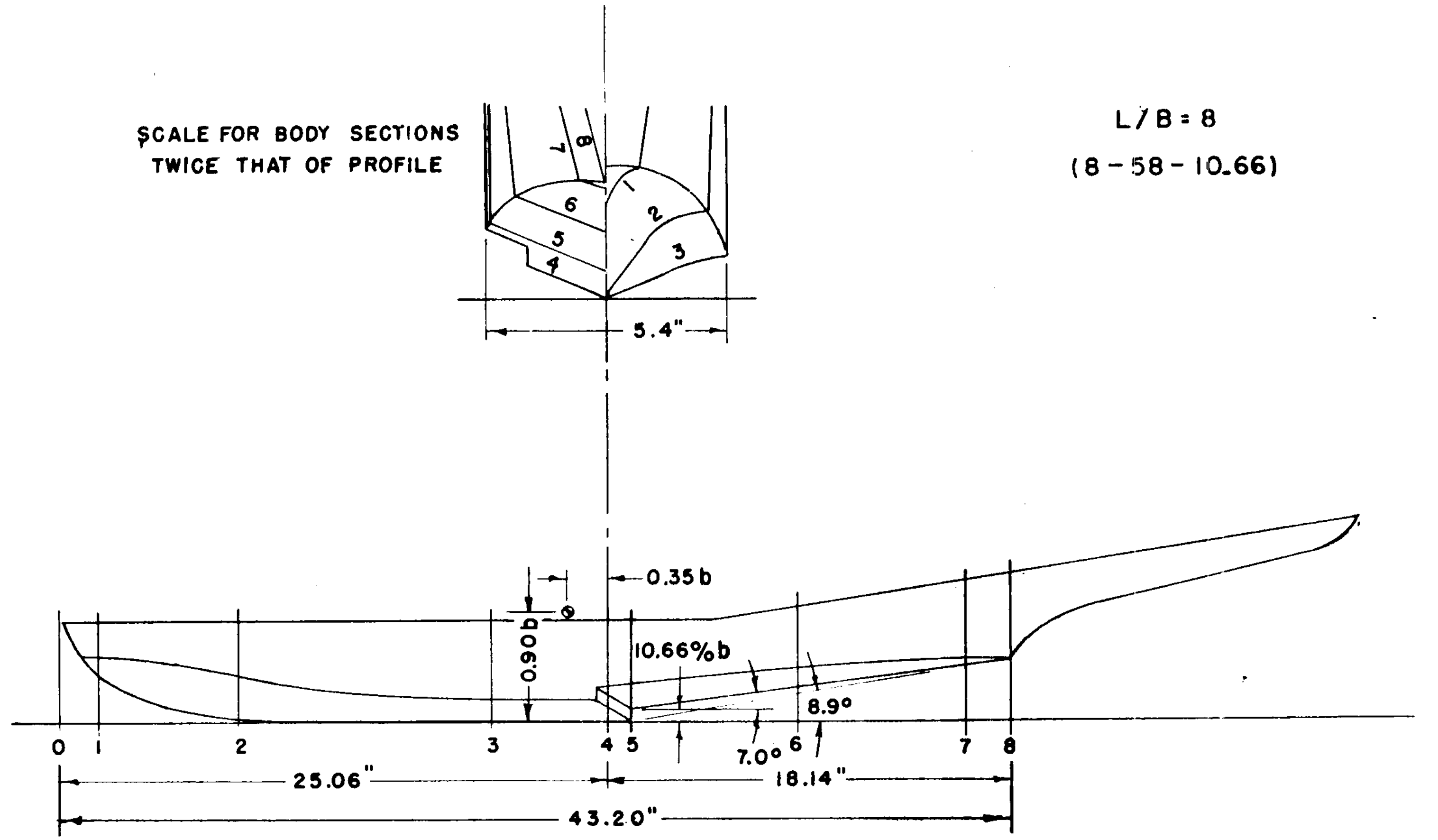


LOAD COEFFICIENT, $C_{\Delta_0}$ (NOMINAL) = 1.80

HULL LINES
MODEL NO. 634

REFERENCE: N.A.C.A. CONTRACT: NO. NAW 3688

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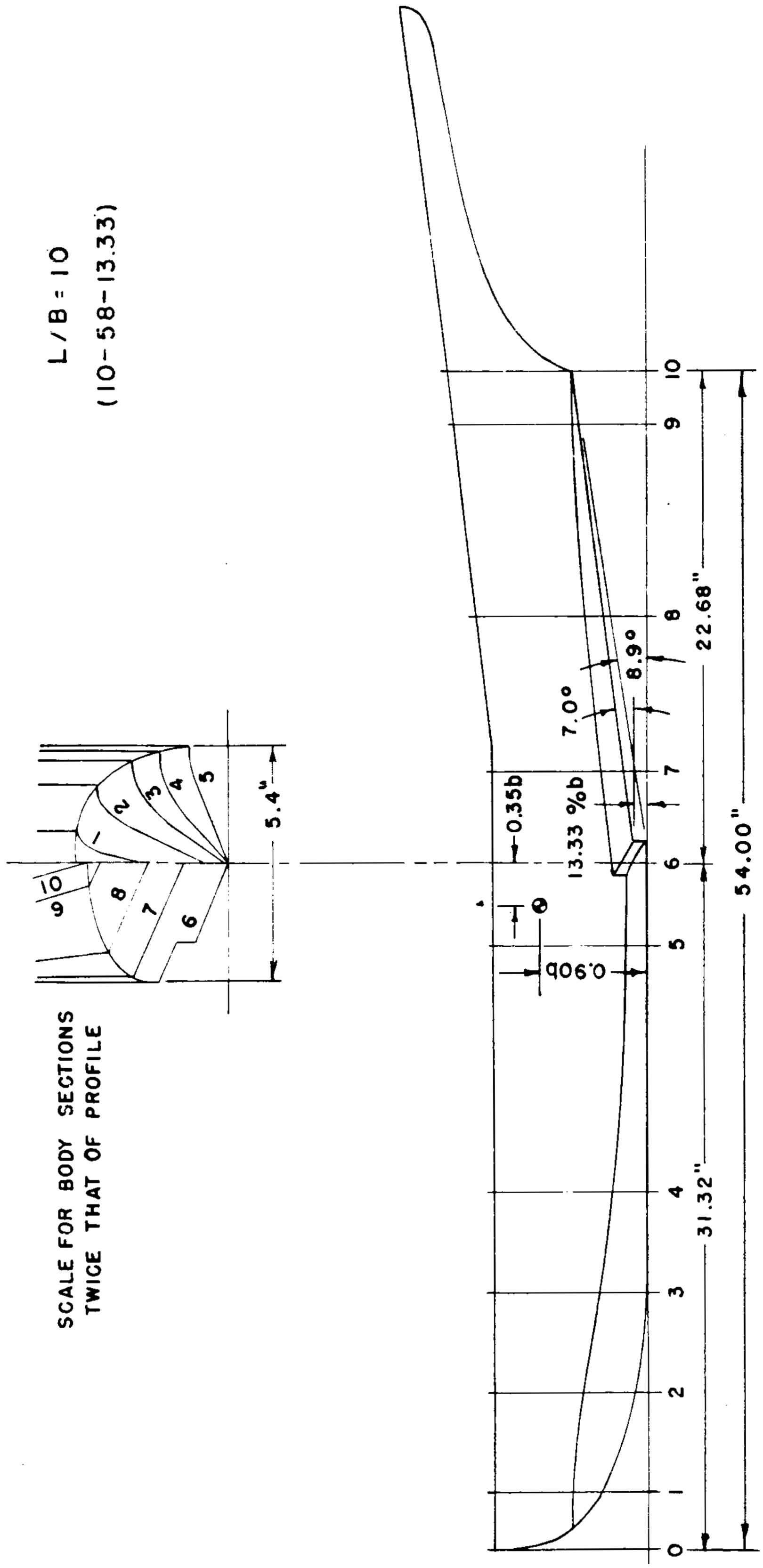
# HULL LINES
# MODEL NO. 685

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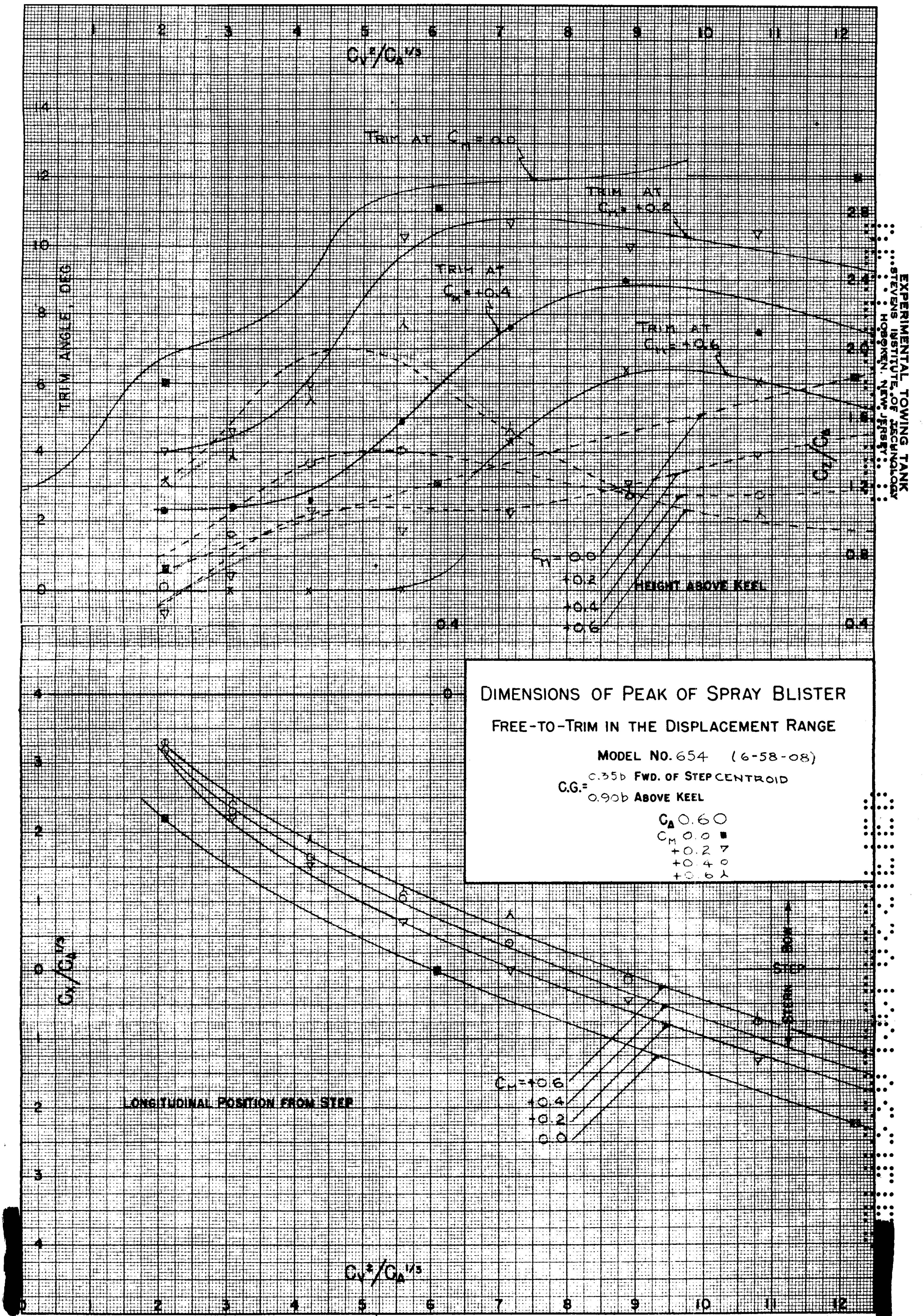
REFERENCE: N.A.C.A. CONTRACT NO. NAW 3688

[redacted]



DIMENSIONS OF PEAK OF SPRAY BLISTER
FREE-TO-TRIM IN THE DISPLACEMENT RANGE
MODEL NO. 654 (6-58-08)
C.G.= 0.35b FWD. OF STEP CENTROID
0.90b ABOVE KEEL
$C_\Delta$ 0.60
$C_M$ 0.0
+0.2
+0.4
+0.6
TRIM AT $C_M$ = 0.0
TRIM AT $C_M$ = +0.2
TRIM AT $C_M$ = +0.4
TRIM AT $C_M$ = +0.6
TRIM ANGLE, DEG
$C_Z/C_B$
HEIGHT ABOVE KEEL
$C_M$ = 0.0
+0.2
+0.4
+0.6
$C_V^2/C_\Delta^{1/3}$
$C_X/C_\Delta^{1/3}$
LONGITUDINAL POSITION FROM STEP
$C_M$ = +0.6
+0.4
+0.2
0.0
BOW
STEP
STERN
EXPERIMENTAL TOWING TANK
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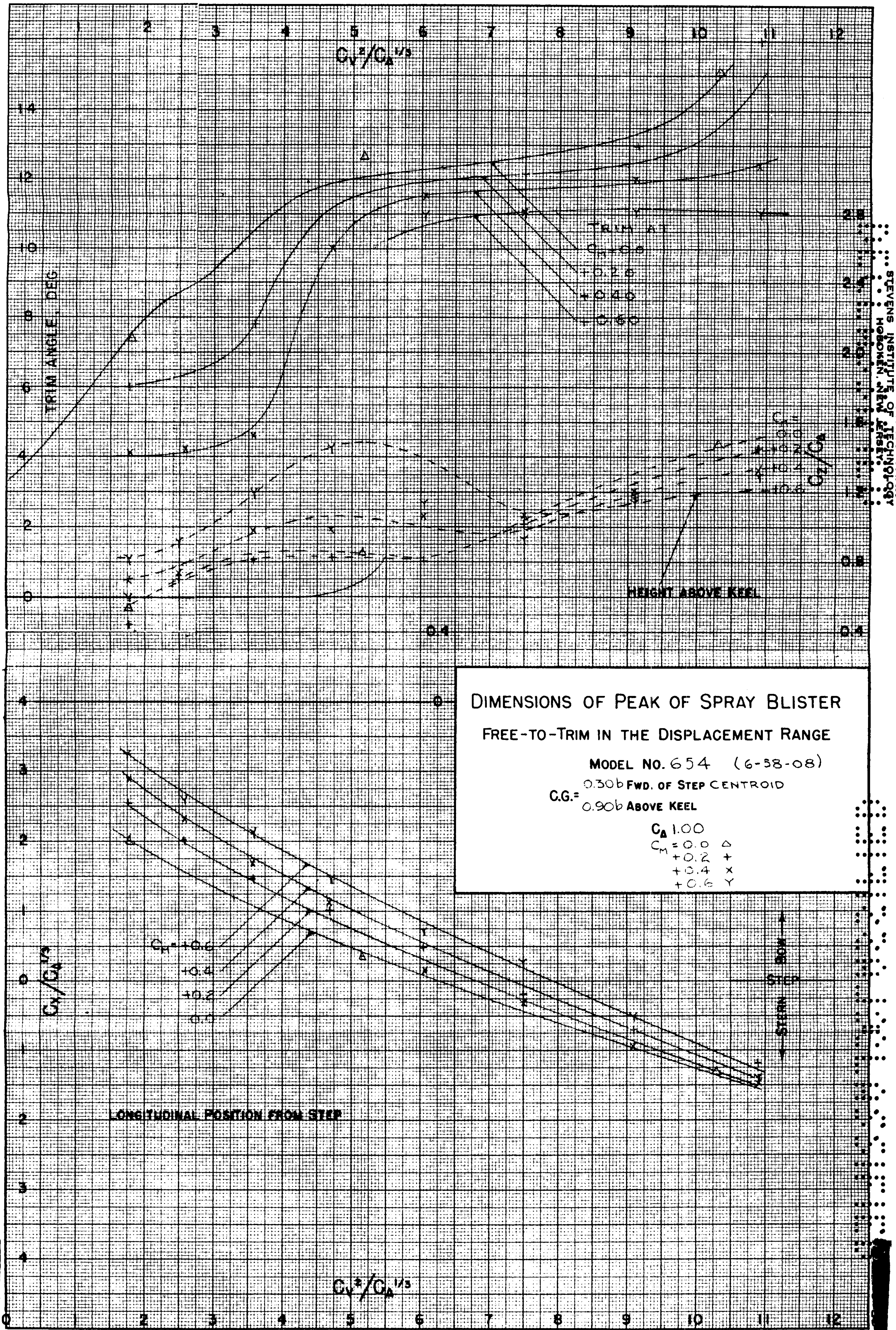

DIMENSIONS OF PEAK OF SPRAY BLISTER
FREE-TO-TRIM IN THE DISPLACEMENT RANGE
MODEL NO. 654 (6-58-08)
C.G.= 0.30b FWD. OF STEP CENTROID
0.90b ABOVE KEEL
$C_\Delta$ 1.00
$C_M$ = 0.0 △
+0.2 +
+0.4 ×
+0.6 Y
$C_V^2/C_\Delta^{1/3}$
TRIM ANGLE, DEG.
TRIM AT
$C_M$ = 0.0
+0.20
+0.40
+0.60
$C_Z/C_\Delta$
$C_M$ = 0.0
+0.2
+0.4
+0.6
HEIGHT ABOVE KEEL
$C_X/C_\Delta^{1/3}$
$C_M$ = +0.6
+0.4
+0.2
0.0
BOW
STEP
STERN
LONGITUDINAL POSITION FROM STEP
EXPERIMENTAL TOWING TANK
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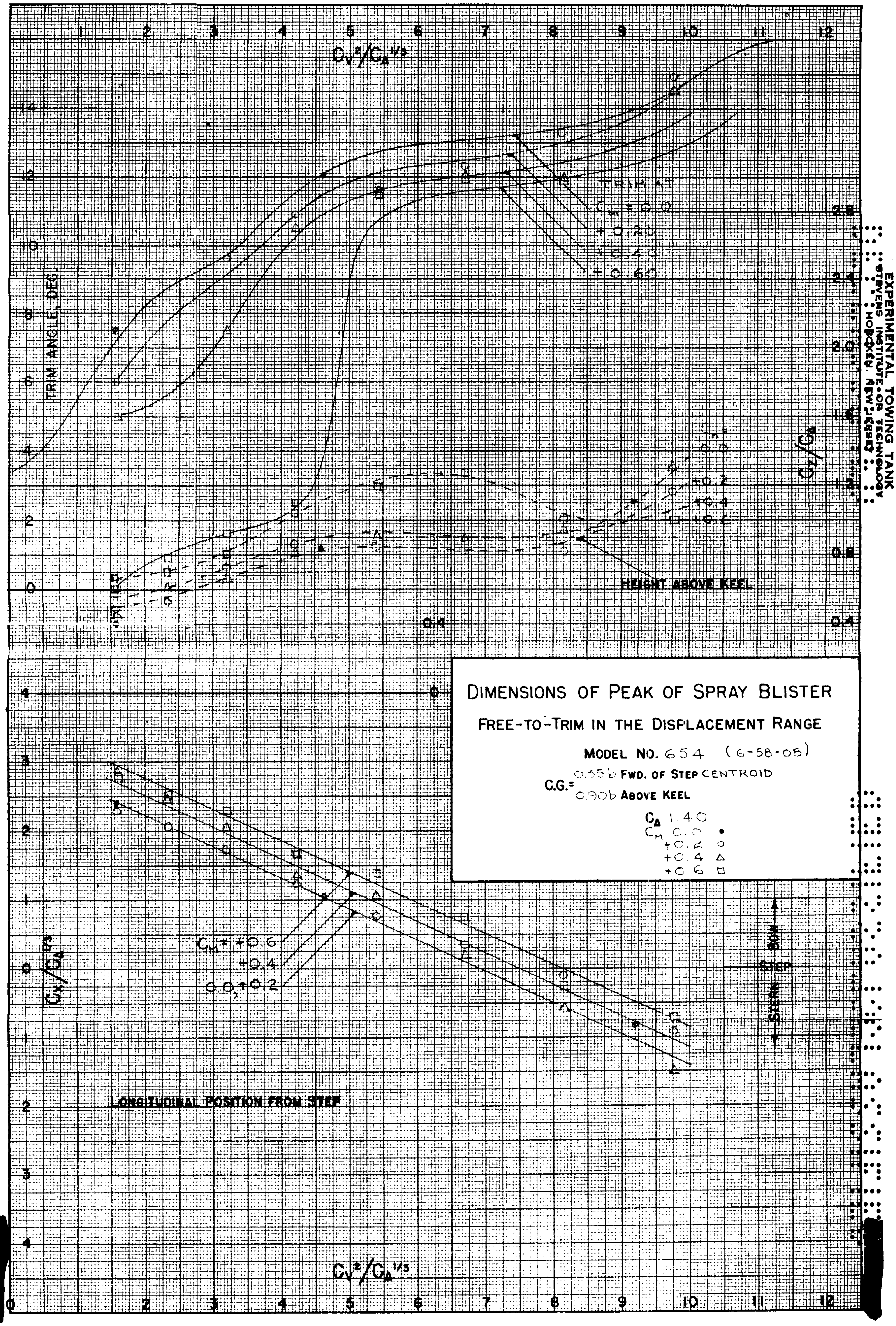

DIMENSIONS OF PEAK OF SPRAY BLISTER
FREE-TO-TRIM IN THE DISPLACEMENT RANGE
MODEL NO. 654 (6-58-08)
C.G.= 0.55b FWD. OF STEP CENTROID
0.90b ABOVE KEEL
$C_\Delta$ 1.40
$C_M$ 0.0 •
+0.2 ○
+0.4 △
+0.6 □
$C_V^2/C_\Delta^{1/3}$
TRIM ANGLE, DEG.
TRIM AT
$C_M$ = 0.0
+0.20
+0.43
+0.60
$C_Z/C_\Delta$
$C_M$
0.0
+0.2
+0.4
+0.6
HEIGHT ABOVE KEEL
$C_X/C_\Delta^{1/3}$
$C_M$ = +0.6
+0.4
0.0, +0.2
LONGITUDINAL POSITION FROM STEP
BOW
STEP
STERN
EXPERIMENTAL TOWING TANK
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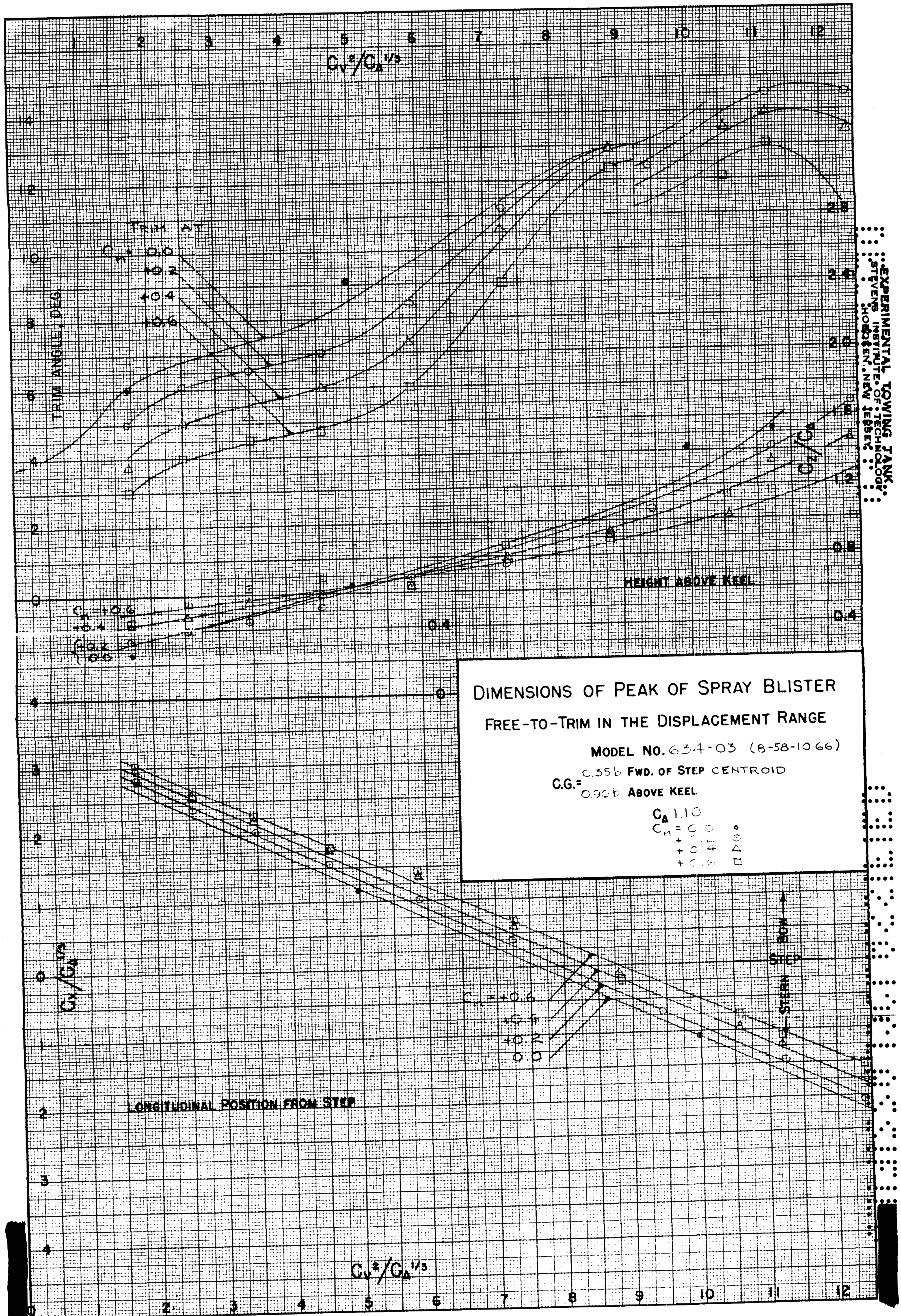

DIMENSIONS OF PEAK OF SPRAY BLISTER
FREE-TO-TRIM IN THE DISPLACEMENT RANGE
MODEL NO. 634-03 (8-58-10.66)
C.G. = 0.55b FWD. OF STEP CENTROID
0.90b ABOVE KEEL
$C_\Delta$ 1.10
$C_M$ = 0.0
+0.2
+0.4
+0.6
TRIM AT
$C_M$ = 0.0
+0.2
+0.4
+0.6
TRIM ANGLE, DEG.
$C_V^2/C_\Delta^{1/3}$
$C_Z/C_\Delta$
HEIGHT ABOVE KEEL
$C_X/C_\Delta^{1/3}$
LONGITUDINAL POSITION FROM STEP
BOW
STEP
STERN
EXPERIMENTAL TOWING TANK
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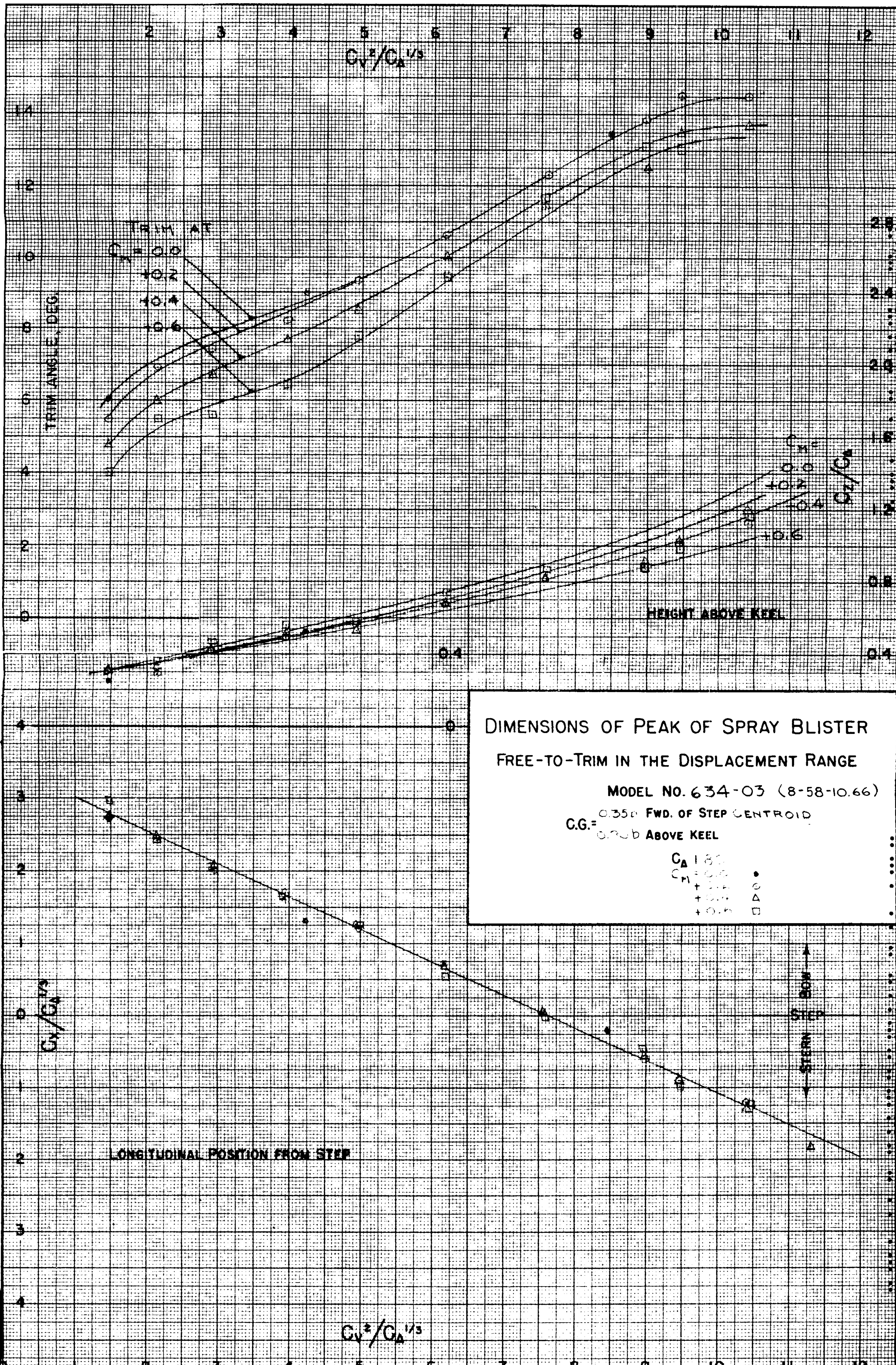


DIMENSIONS OF PEAK OF SPRAY BLISTER

FREE-TO-TRIM IN THE DISPLACEMENT RANGE

MODEL NO. 634-03 (8-58-10.66)

C.G. = 0.35b FWD. OF STEP CENTROID
[illegible] b ABOVE KEEL

$C_\Delta$ 1.8[illegible]
$C_M$ = 0.0 ●
+ 0.2 ○
+ 0.4 △
+ 0.6 □

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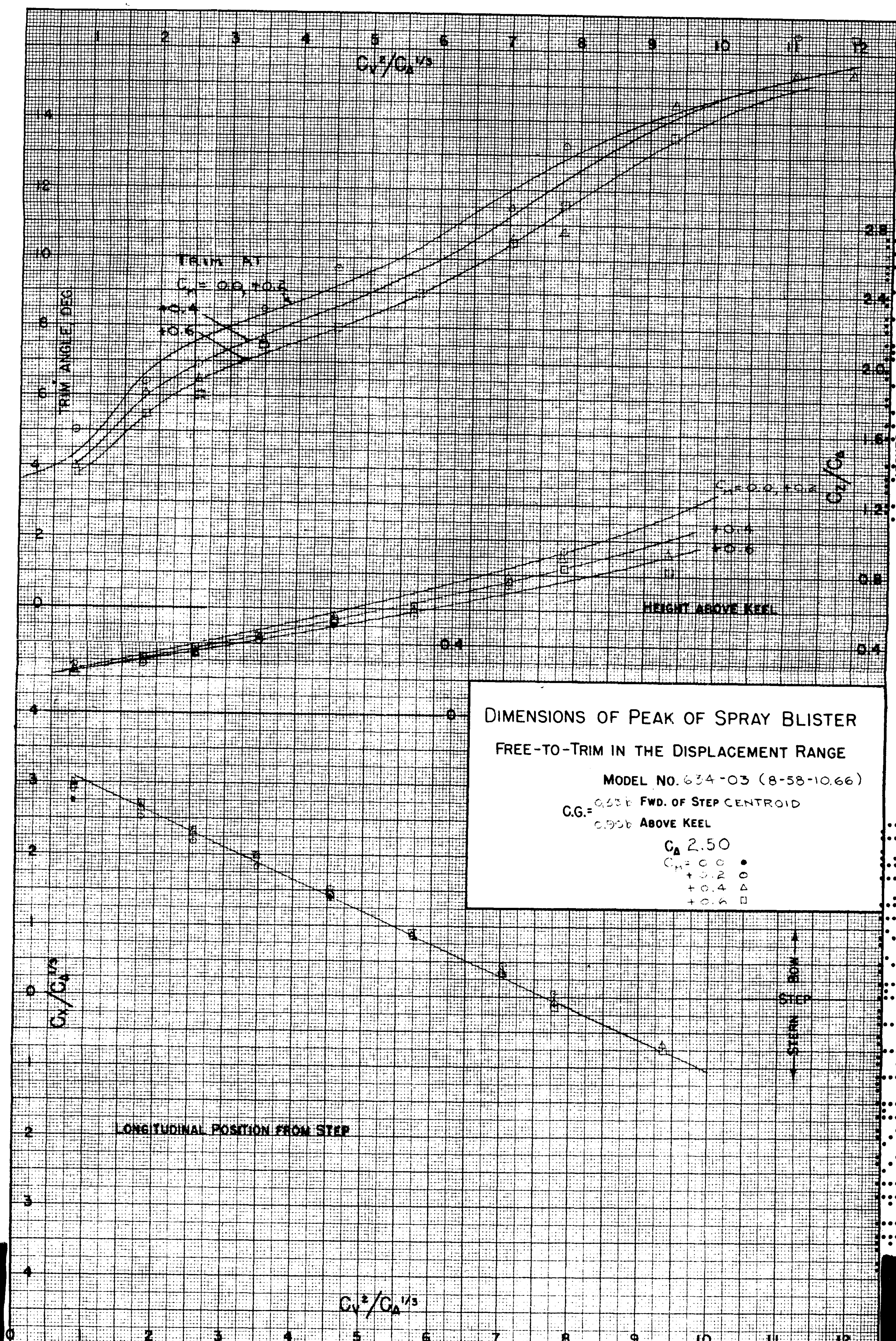


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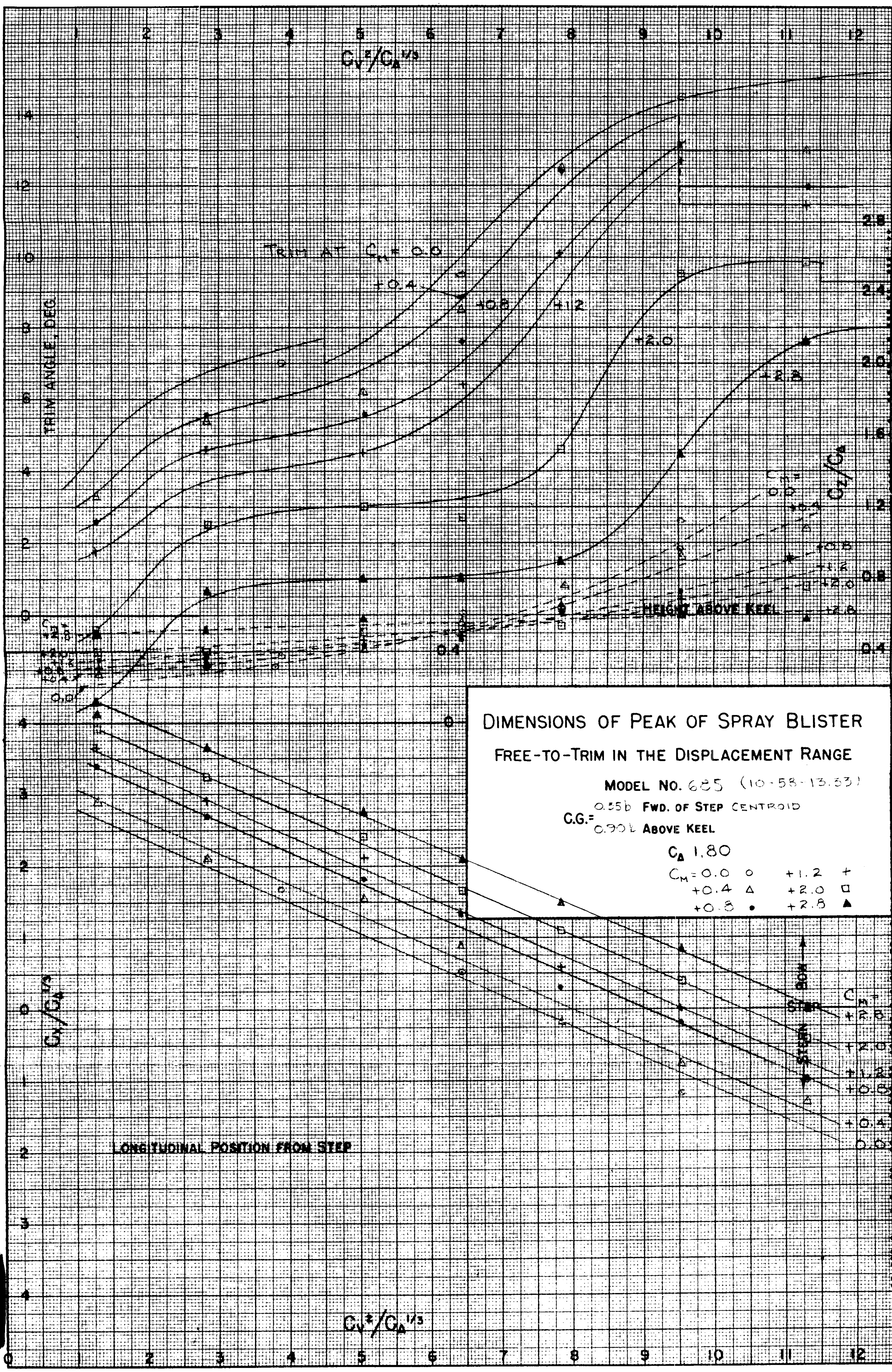


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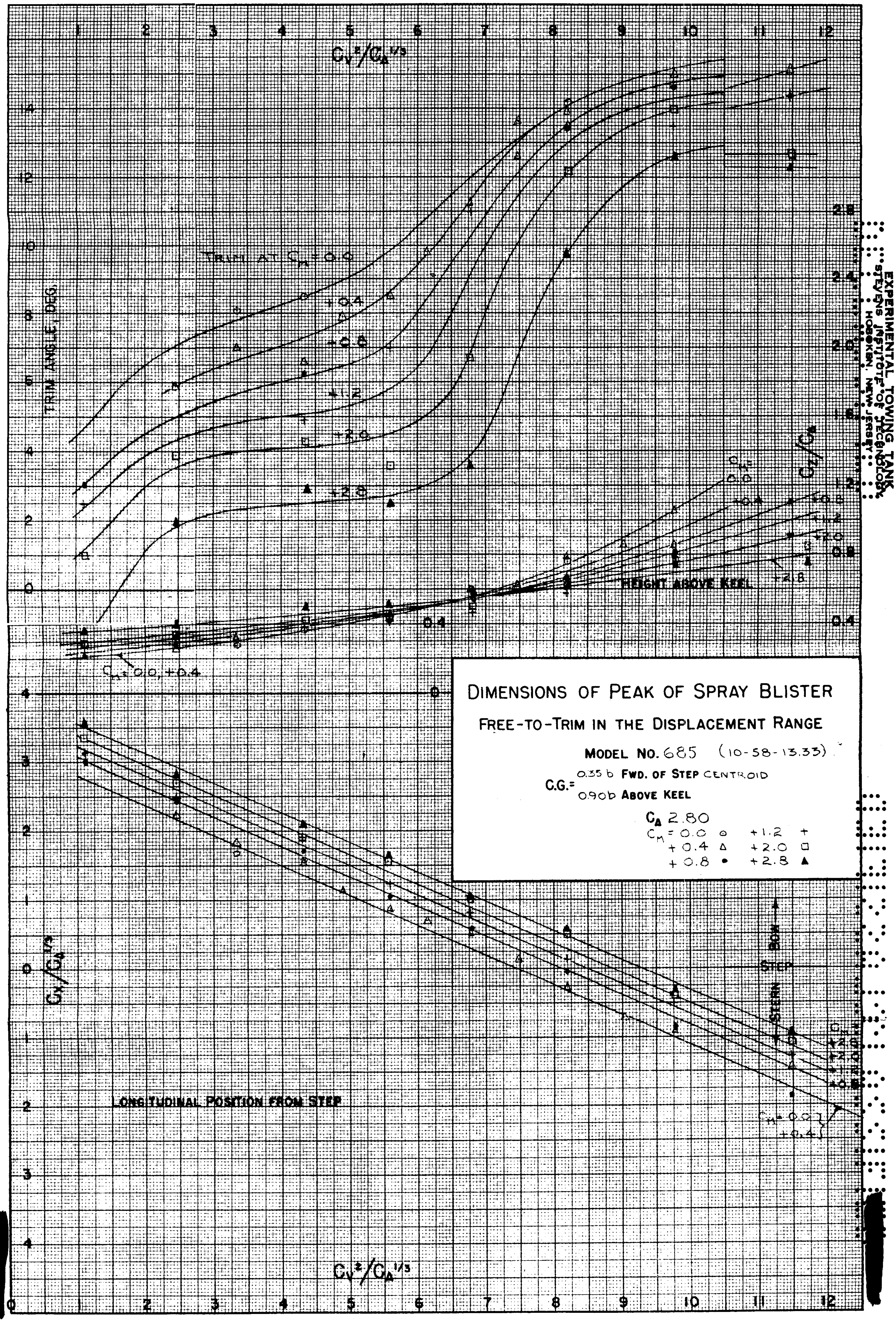

$C_V^2/C_\Delta^{1/3}$
TRIM ANGLE, DEG.
TRIM AT $C_M$ = 0.0
+0.4
+0.8
+1.2
+2.0
+2.8
$C_Z/C_\Delta$
HEIGHT ABOVE KEEL
$C_M$ = 0.0, +0.4
$C_X/C_\Delta^{1/3}$
LONGITUDINAL POSITION FROM STEP
BOW
STEP
STERN
DIMENSIONS OF PEAK OF SPRAY BLISTER
FREE-TO-TRIM IN THE DISPLACEMENT RANGE
MODEL NO. 685 (10-58-13.33)
C.G. = 0.35 b FWD. OF STEP CENTROID
0.90 b ABOVE KEEL
$C_\Delta$ 2.80
$C_M$ = 0.0 ○ +1.2 +
+0.4 △ +2.0 □
+0.8 ● +2.8 ▲
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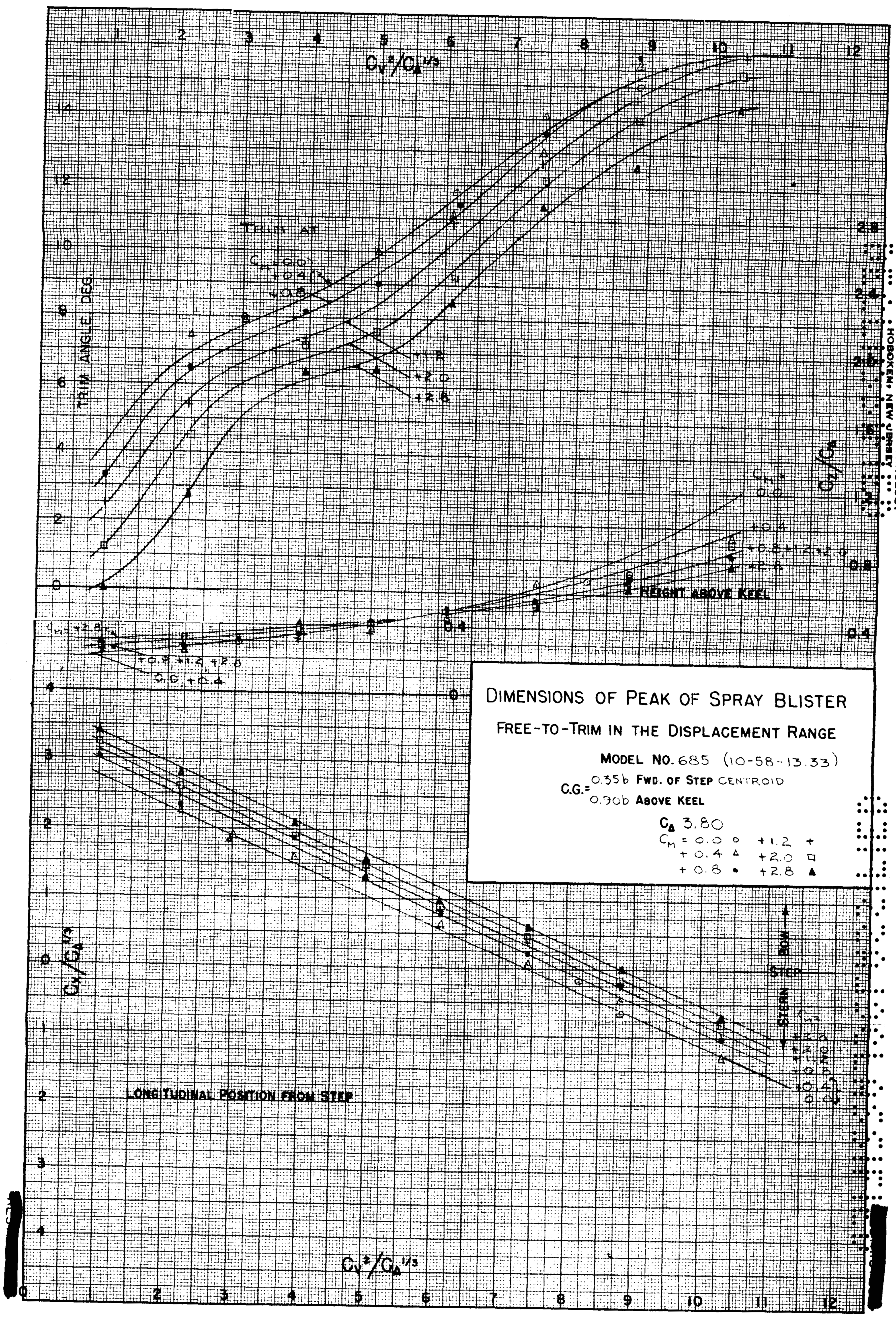


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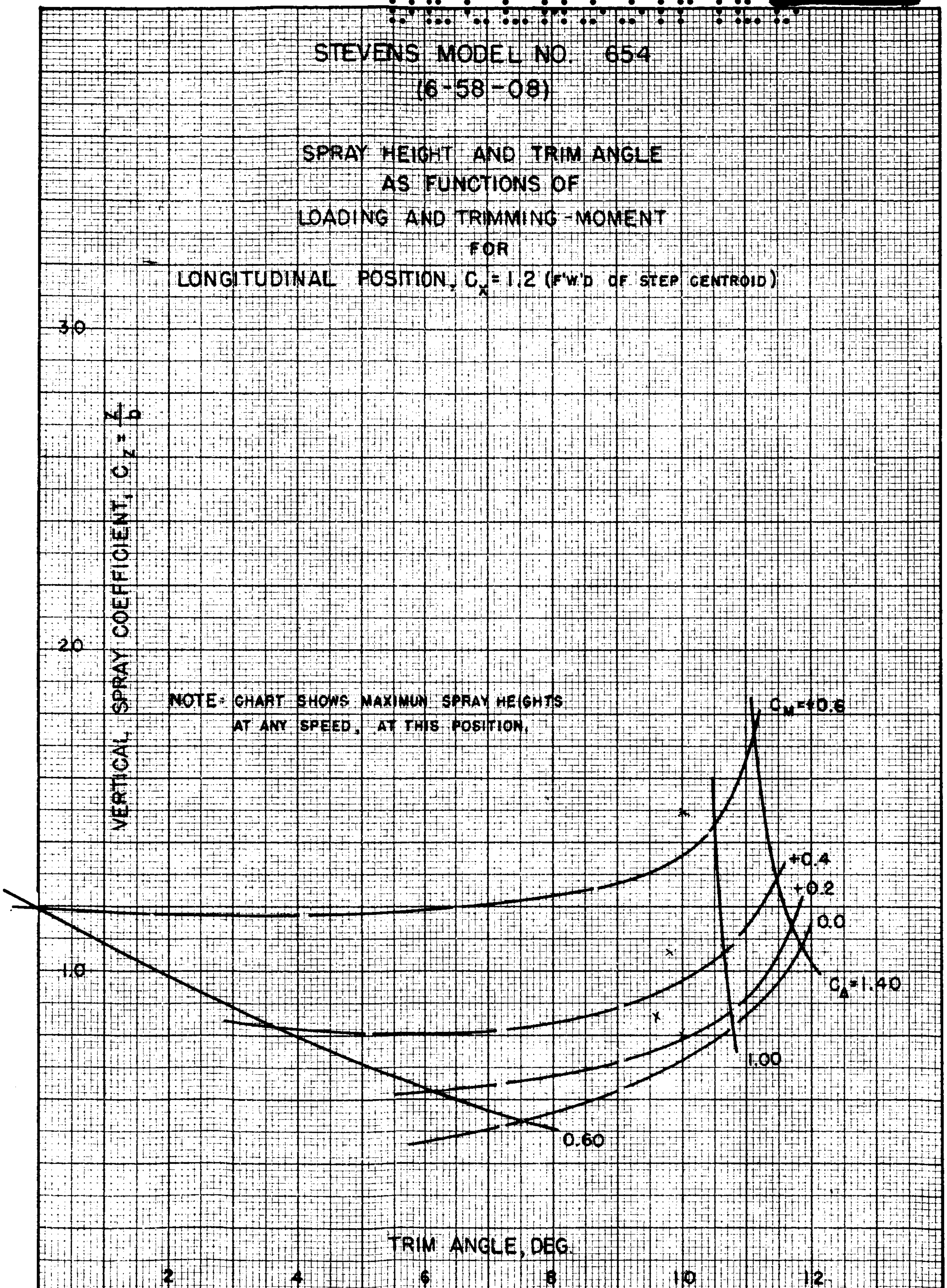
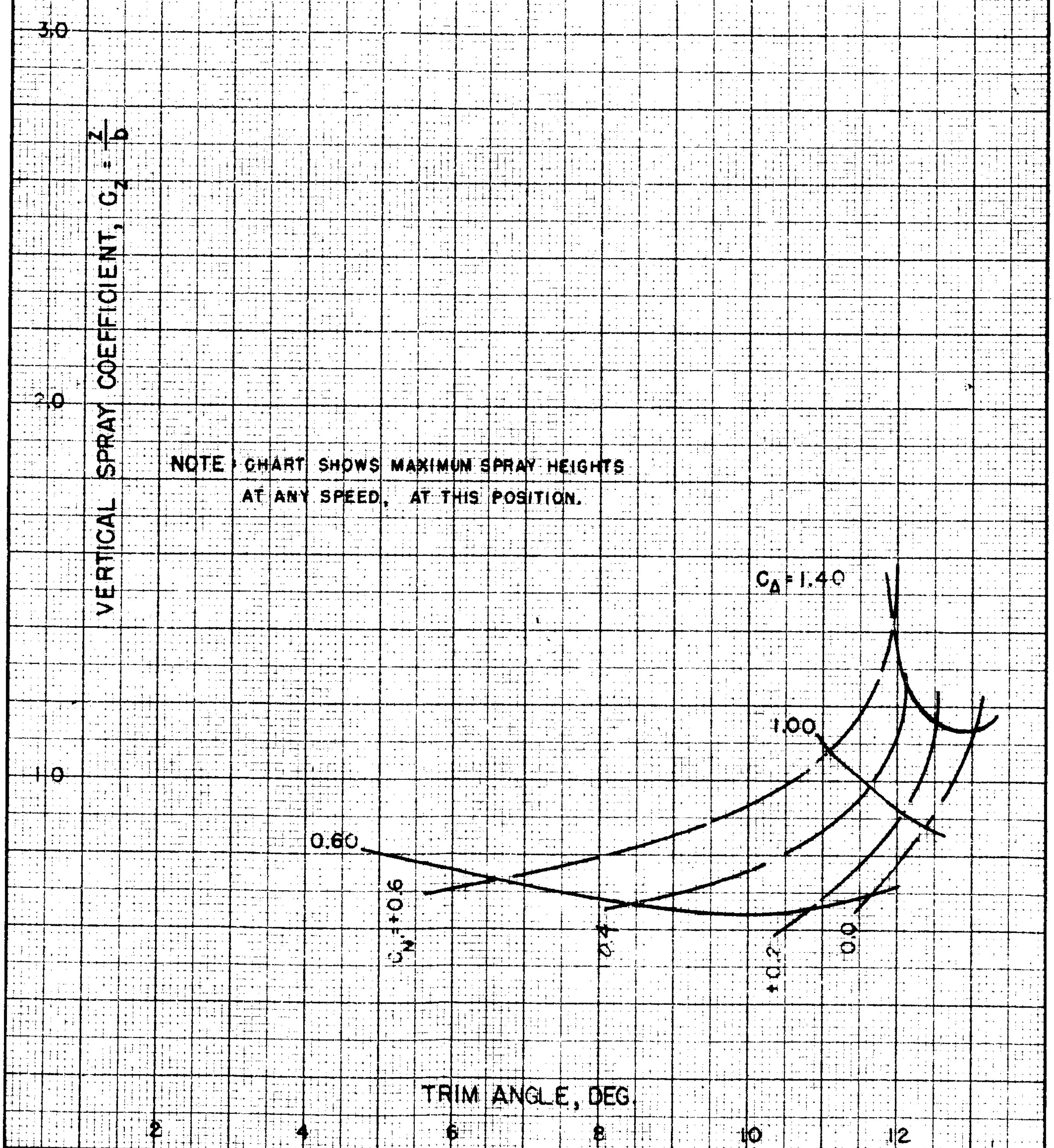

STEVENS MODEL NO. 654
(6-58-08)
SPRAY HEIGHT AND TRIM ANGLE
AS FUNCTIONS OF
LOADING AND TRIMMING-MOMENT
FOR
LONGITUDINAL POSITION, $C_x$ = 1.2 (F'W'D OF STEP CENTROID)
VERTICAL SPRAY COEFFICIENT, $C_z = \frac{Z}{b}$
3.0
2.0
1.0
NOTE: CHART SHOWS MAXIMUM SPRAY HEIGHTS
AT ANY SPEED, AT THIS POSITION.
$C_M$=+0.6
+0.4
+0.2
0.0
$C_\Delta$=1.40
1.00
0.60
TRIM ANGLE, DEG.
2
4
6
8
10
12

[redacted]

STEVENS MODEL NO. 654
(6-58-08)

SPRAY HEIGHT AND TRIM ANGLE
AS FUNCTIONS OF
LOADING AND TRIMMING-MOMENT
FOR
LONGITUDINAL POSITION, $C_x = 0.0$ (AT STEP CENTROID)



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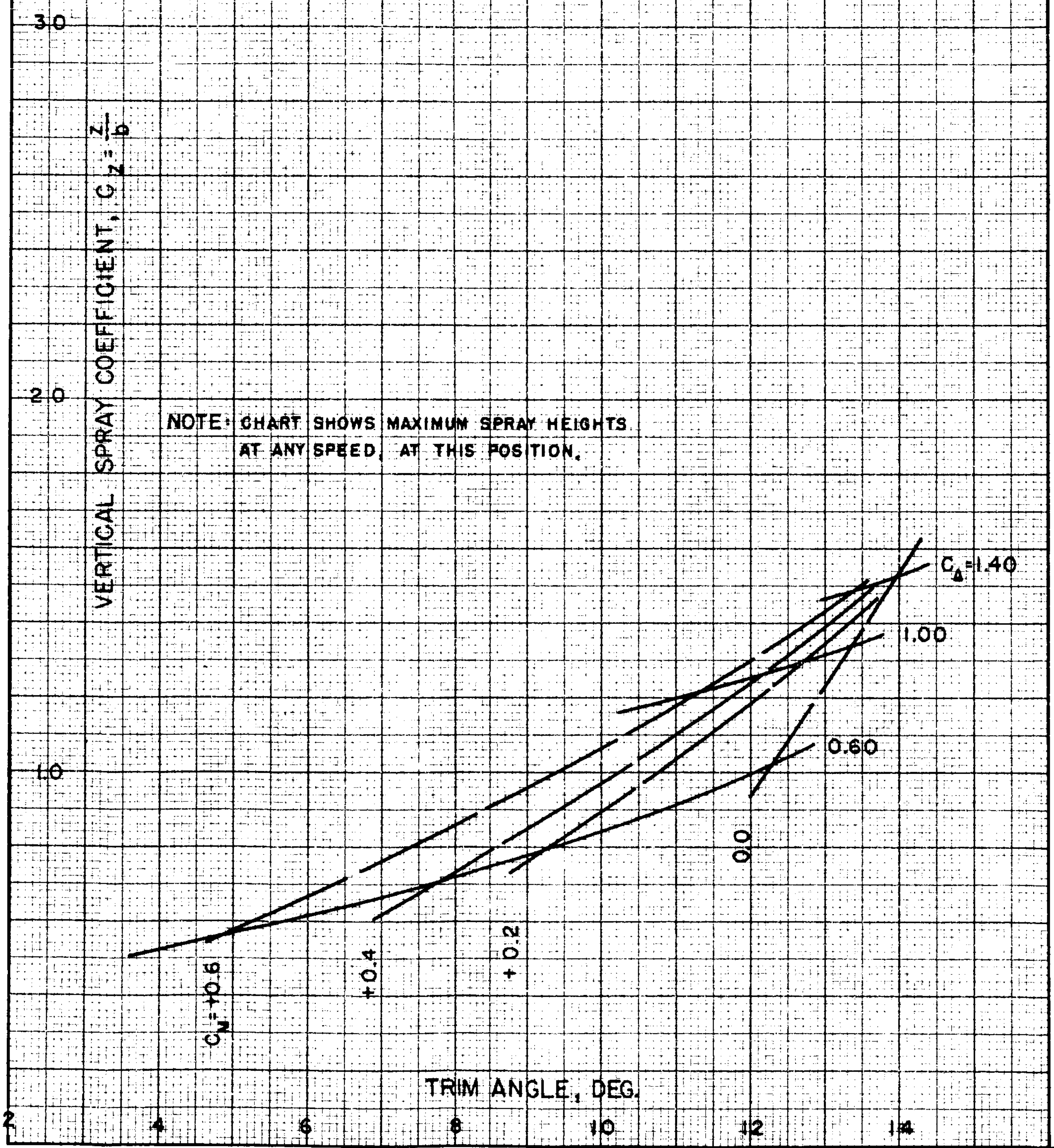
# STEVENS MODEL NO. 654
## (6-58-08)

### SPRAY HEIGHT AND TRIM ANGLE AS FUNCTIONS OF LOADING AND TRIMMING-MOMENT FOR LONGITUDINAL POSITION, $C_X = 1.2$ (AFT OF STEP CENTROID)




FILE

INITIALS

DATE

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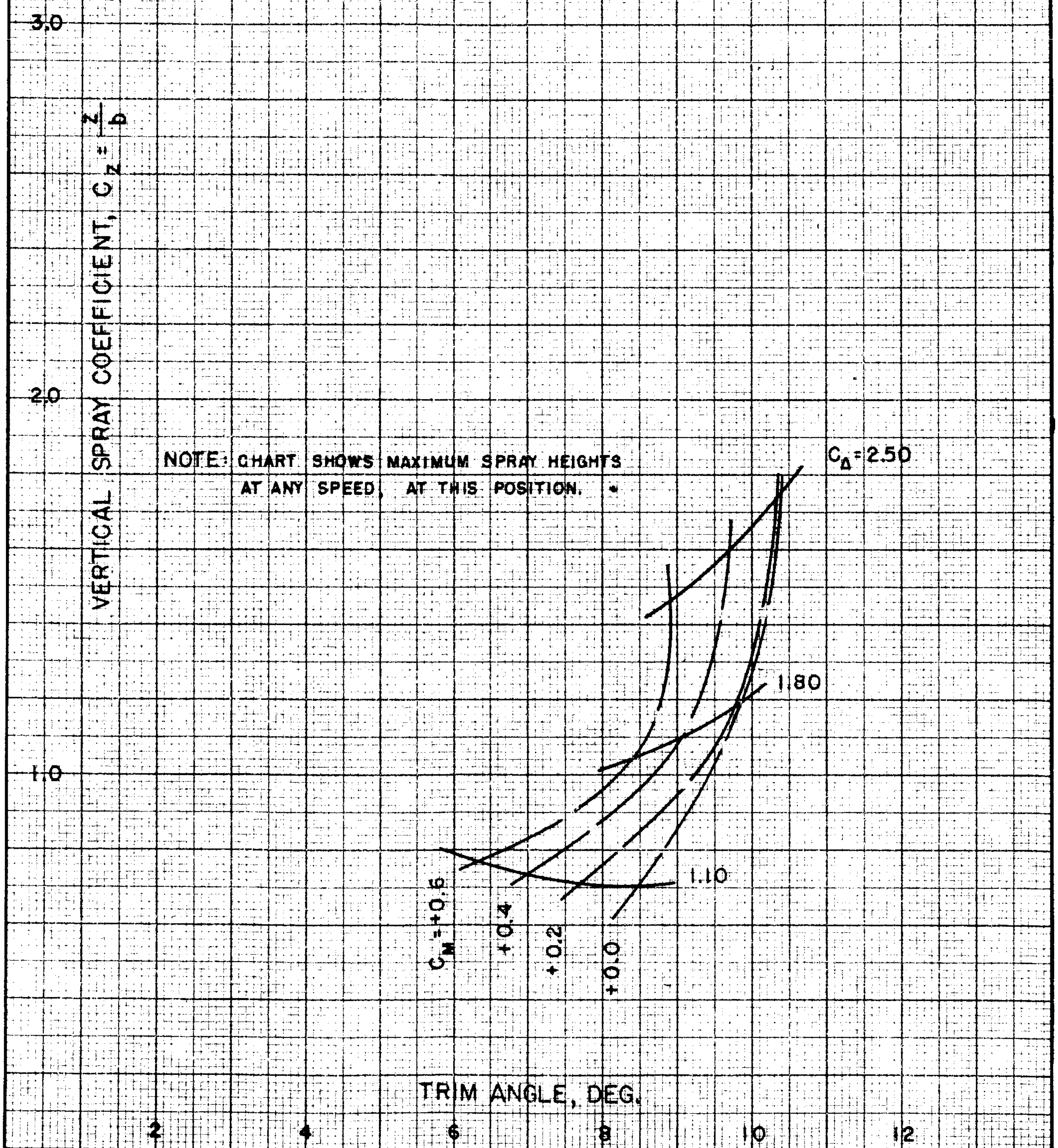
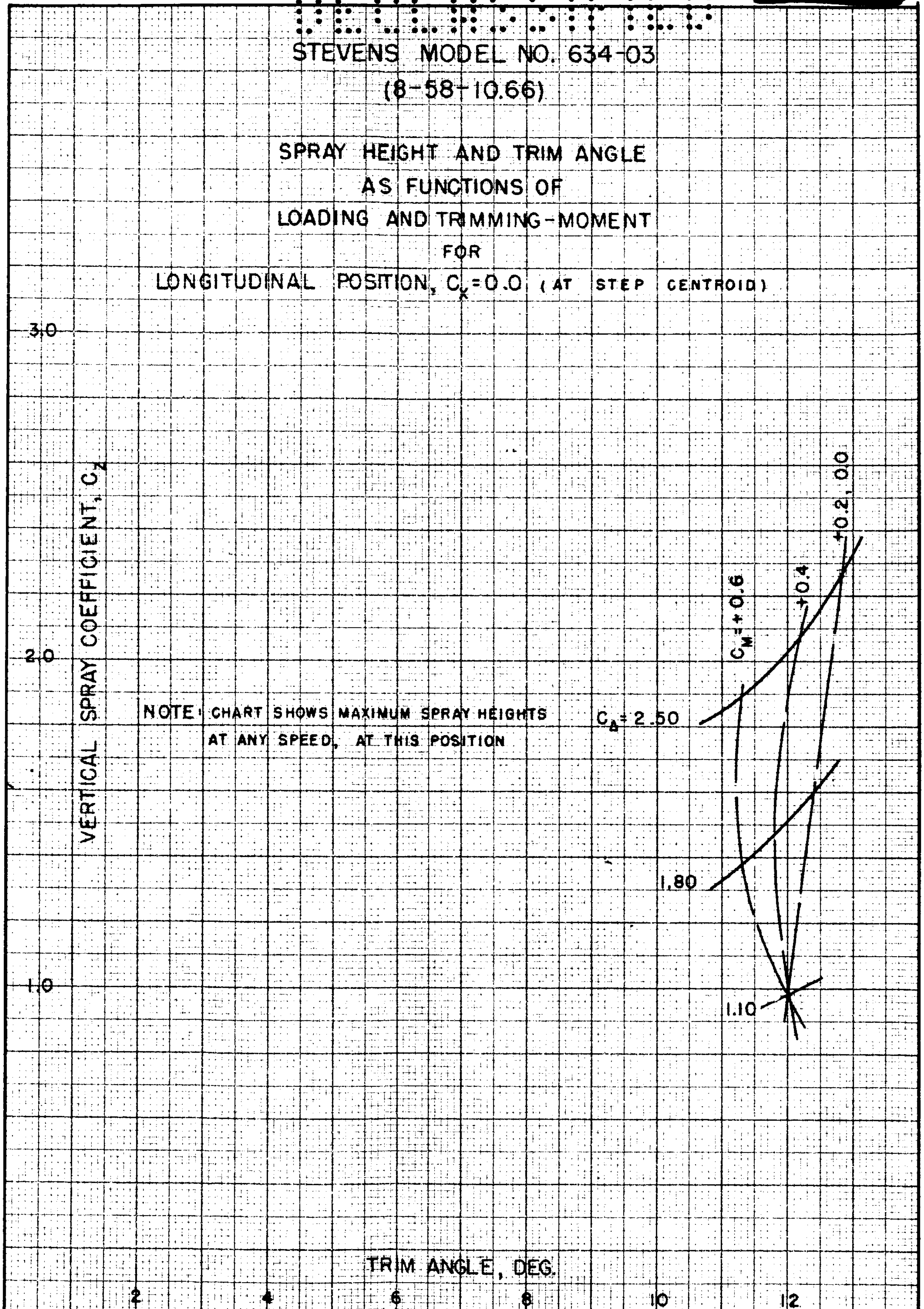
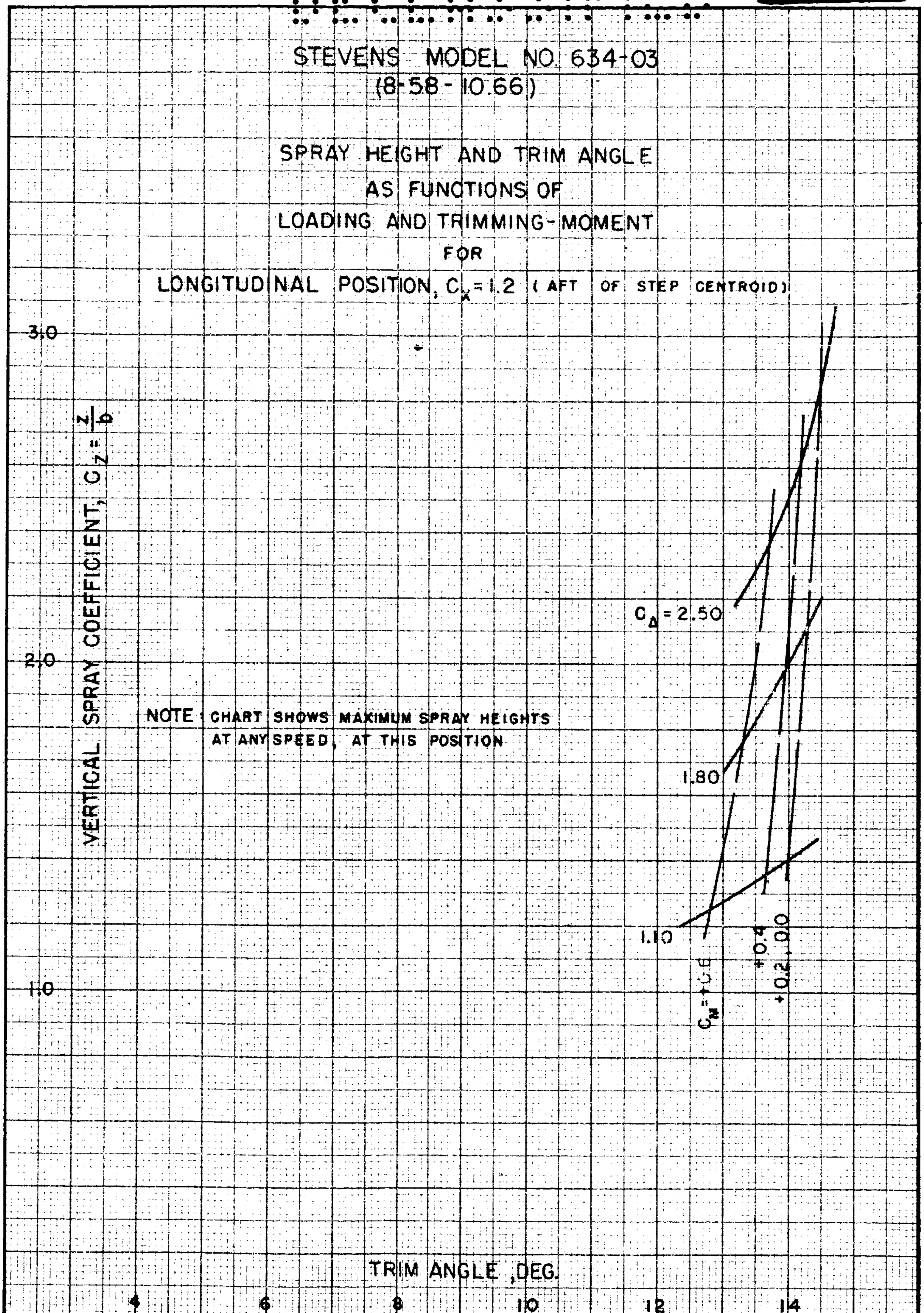
STEVENS MODEL NO. 634-03
(8-58-10.66)

SPRAY HEIGHT AND TRIM ANGLE
AS FUNCTIONS OF
LOADING AND TRIMMING-MOMENT
FOR
LONGITUDINAL POSITION, $C_x = 1.2$ (F'W'D OF STEP CENTROID)




STEVENS MODEL NO. 634-03
(8-58-10.66)
SPRAY HEIGHT AND TRIM ANGLE
AS FUNCTIONS OF
LOADING AND TRIMMING-MOMENT
FOR
LONGITUDINAL POSITION, $C_x$=0.0 (AT STEP CENTROID)
NOTE: CHART SHOWS MAXIMUM SPRAY HEIGHTS
AT ANY SPEED, AT THIS POSITION
VERTICAL SPRAY COEFFICIENT, $C_Z$
TRIM ANGLE, DEG.
3.0
2.0
1.0
2
4
6
8
10
12
$C_\Delta$ = 2.50
1.80
1.10
$C_M$ = +0.6
+0.4
+0.2, 0.0

[redacted]

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DATE

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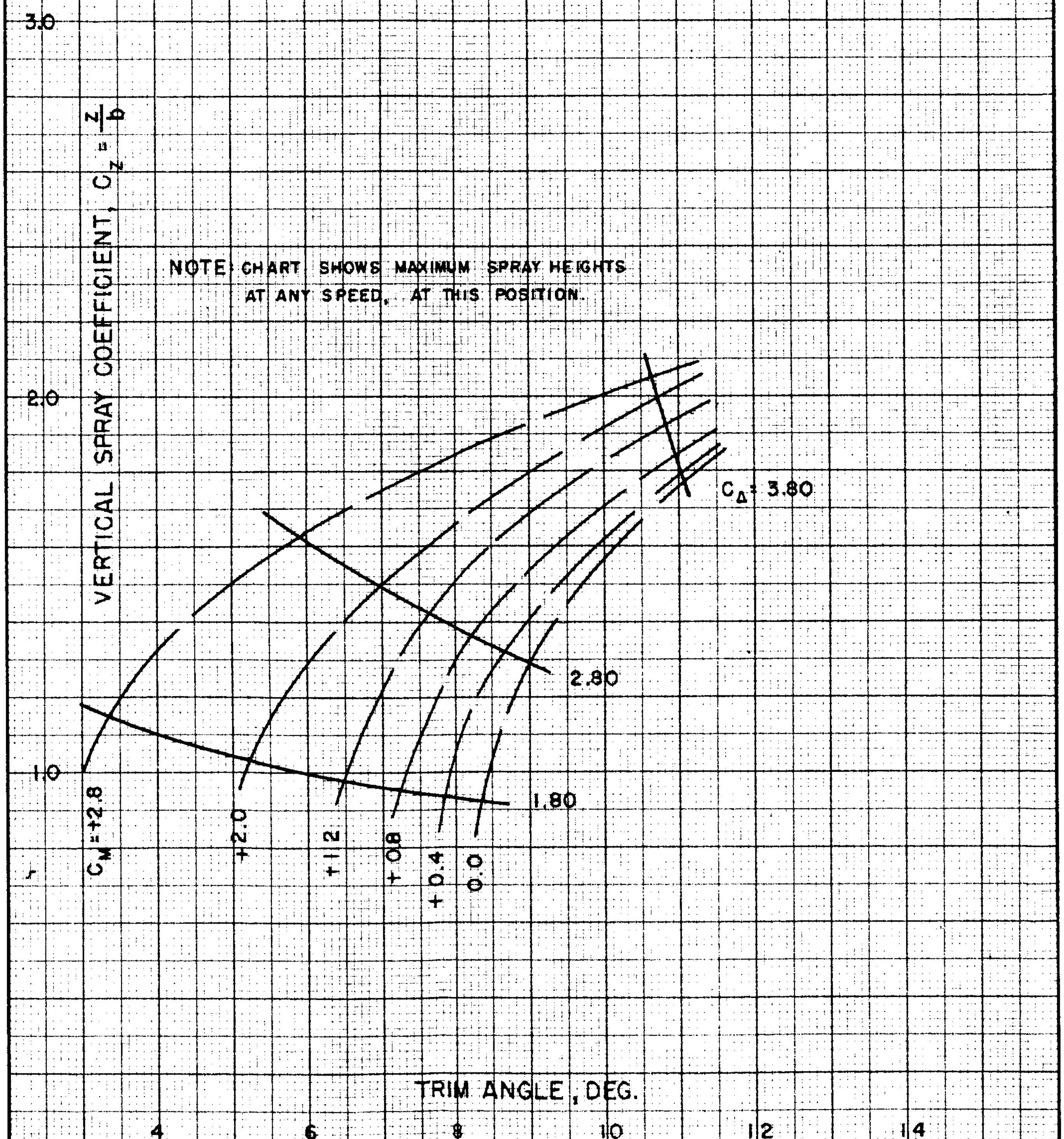
STEVENS MODEL NO. 685
(10-58-13.33)

SPRAY HEIGHT AND TRIM ANGLE
AS FUNCTIONS OF
LOADING AND TRIMMING-MOMENT
FOR
LONGITUDINAL POSITION $C_x$ =1.2 (F'W'D OF STEP CENTROID)



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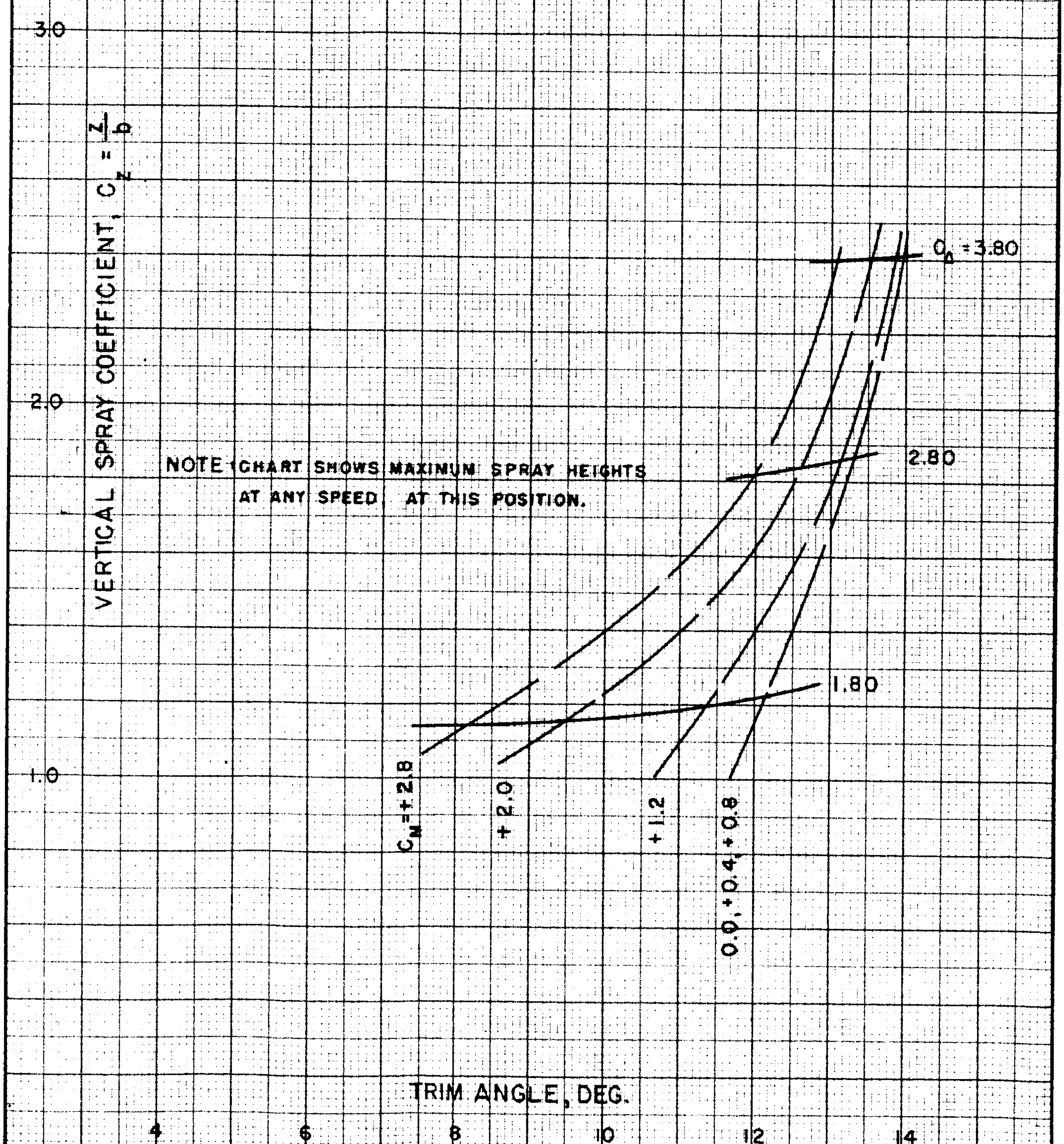
STEVENS MODEL NO. 685
(10-58-13.33)

SPRAY HEIGHT AND TRIM ANGLE
AS FUNCTIONS OF
LOADING AND TRIMMING-MOMENT
FOR
LONGITUDINAL POSITION, $C_x = 0.0$ (AT STEP CENTROID)



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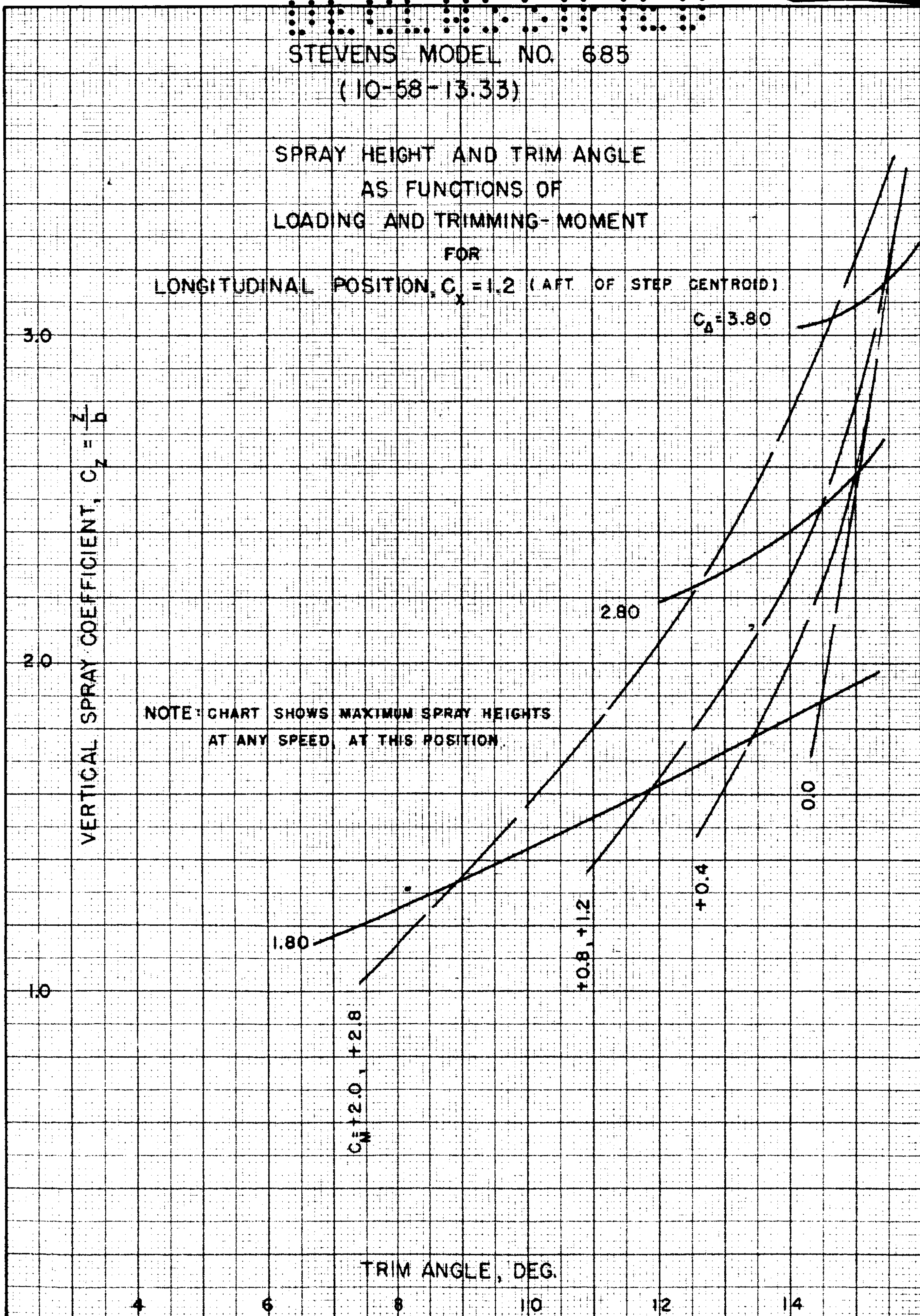


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